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WELLS ST JOHN ROBERTS GREGORY AND MATKIN
SUITE 1300
601 W FIRST AVENUE
SPOKANE, WA 992013828

EXAMINER

KIELIN, ERIK J

ART UNIT	PAPER NUMBER
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2813

DATE MAILED: 12/27/2001

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.

09/388,826

Applicant(s)

Li et al.

Examiner

Erik-Kielin

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136 (a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on Sep 25, 2001
- 2a) ☒ This action is **FINAL**. 2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11; 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 66-101 is/are pending in the application.
- 4a) Of the above, claim(s) 66-80 is/are withdrawn from consideration:
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 81-101 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claims _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are objected to by the Examiner.
- 11) ☐ The proposed drawing correction filed on _____ is: a) ☐ approved b) ☐ disapproved.
- 12) ☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. § 119

- 13) ☐ Acknowledgement is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d).
- a) ☐ All b) ☐ Some* c) ☐ None of:
- ☐ Certified copies of the priority documents have been received.
 - ☐ Certified copies of the priority documents have been received in Application No. _____.
 - ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- *See the attached detailed Office action for a list of the certified copies not received.
- 14) ☐ Acknowledgement is made of a claim for domestic priority under 35 U.S.C. § 119(e).

Attachment(s)

- 15) ☐ Notice of References Cited (PTO-892)
- 16) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 17) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) 17, 18
- 18) ☐ Interview Summary (PTO-413) Paper No(s) _____
- 19) ☐ Notice of Informal Patent Application (PTO-152)
- 20) ☐ Other: _____

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DETAILED ACTION

Election/Restriction

1. Newly submitted claims 66-80 are directed to an invention that is independent or distinct from the invention originally claimed for the following reasons:

The new claims are drawn to a method of forming a layer of $(\text{CH}_3)_x\text{SiO}_y$ by first depositing a layer of plasma-exposed methylsilane --without oxygen-- and then converting the layer to $(\text{CH}_3)_x\text{SiO}_y$ by an oxygen exposure, as is made clear in the specification, in the paragraph bridging pages 9-10. Note that the specification states that **“a whole of the deposited dielectric layer is transformed** from one base chemistry (i.e., that comprising a nondescript combination of methyl groups and silicon) to another base chemistry (i.e. $(\text{CH}_3)_x\text{SiO}_y$) by the oxygen exposure.” (Emphasis added.)

To the contrary, the originally filed claims were drawn to a method of reducing the dielectric constant of the already deposited $(\text{CH}_3)_x\text{SiO}_y$ by **additional** exposure to oxygen which is **not** the exposure to form the $(\text{CH}_3)_x\text{SiO}_y$ layer, as the specification makes clear in the paragraph bridging pages 10-11. Note additionally, the next paragraph specifically states that the dielectric constant of the $(\text{CH}_3)_x\text{SiO}_y$ layer is reduced -- not the dielectric constant of the “nondescript combination of methyl groups and silicon” which is clearly a different layer. Furthermore, the specification makes clear that this is a sequence of steps. Further in this regard, it is particularly important to note that the specification specifically states, at page 12, lines 3-5, “It is a preferred

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intent of the exposing to further **not transform a whole** of all of the dielectric material from one base chemistry to another base chemistry by the exposing.” (Emphasis added.) This statement would directly contradict that indicated above wherein a whole is transformed, unless these are separate exposures to oxygen.

Accordingly the new claims 66-80 are a different subcombination (the selective method of forming the dielectric $(\text{CH}_3)_x\text{SiO}_y$ layer) usable together with the original subcombination (the method of reducing the dielectric of the $(\text{CH}_3)_x\text{SiO}_y$ layer). None of the originally examined claims included the feature of transforming the whole of the dielectric layer from methyl groups and silicon to $(\text{CH}_3)_x\text{SiO}_y$.

New claims 80-101 are directed to the subject matter originally examined as is made clear by comparing claim 1 to claim 81.

Since applicant has received an action on the merits for the originally presented invention, this invention has been constructively elected by original presentation for prosecution on the merits. Accordingly, claims 66-80 are withdrawn from consideration as being directed to a non-elected invention. See 37 CFR 1.142(b) and MPEP § 821.03.

Claim Rejections - 35 USC § 112

2. The following is a quotation of the first paragraph of 35 U.S.C. 112:

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to

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make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

3. Claims 82-84, 87, 98 are rejected under 35 U.S.C. 112, first paragraph, as containing subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention.

Regarding claims 82-84, and 87, Applicant's specification expressly defines "dry" as directed to the oxygen-comprising "precursor" used to form the initial $(\text{CH}_3)_x\text{SiO}_y$ layer -- not for the oxygen exposure used to reduce the dielectric constant of the as-formed $(\text{CH}_3)_x\text{SiO}_y$ layer, as noted above under the section regarding the restriction requirement. (See also specification at page 7, lines 5-7.) There is simply no support in the specification for this limitation being directed to the oxygen-exposure step used to reduce the dielectric constant of the $(\text{CH}_3)_x\text{SiO}_y$ layer.

Regarding claim 98, there does not appear to be support for the oxygen plasma exposure time range of 20 seconds to 100 seconds. The specification and the original claims provides enablement only for at least 20 seconds and at least 40, 60, 80, and 100 seconds (specification, page 12, lines 11-13 and original claims 20-24). Accordingly, one of ordinary skill would not expect the range of time to stop at an upper limit of 100 seconds when at least 100 seconds has been indicated by the specification and the claims as originally filed.

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Claim Rejections - 35 USC § 103

4. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

5. Claims 81-88, 90-101 are rejected under 35 U.S.C. 103(a) as unpatentable over **Morita** (JP 63-157443 A) in view of **Matsuura** (US 6,124,641).

Morita discloses forming a low-dielectric-constant material comprising phenyl or alkyl silicon oxide 10 which inherently has a dielectric constant of less than 3.5 over an integrated circuit-Fig. 2; blanket-exposing the dielectric to oxygen-plasma to form an upper surface 11 of silicon oxide which is inherently effective to reduce the dielectric constant. (See Figs. 1-2; page 2, lower two column). Note that a whole of the dielectric layer is not converted from one base to another (Applicant's claim 19) and that the $(\text{CH}_3)_x\text{SiO}_y$ remains as $(\text{CH}_3)_x\text{SiO}_y$. Note that the plasma exposure time is 10 minutes. Regarding claim 14, **Morita** forms the organic silicon oxide layer using $\text{R}_n\text{Si}(\text{OH})_{4-n}$ wherein R is any alkyl group. Examiner repeats the unchallenged official notice that alkyl includes methyl as this is the simplest of the alkyl group members. (See Hackh's, *supra*).

To quote from **Morita** at page 5,

"When this semiconductor substrate 1 is exposed to an oxygen plasma for ten minutes, the organic functional groups of organic silicon thin film 10 are removed to a desired depth, transforming into a silicon oxide film. As such, the film thickness of organic

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silicon thin film 10 as initially formed, in its thinnest portions, transforms **nearly** entirely to silicon oxide film 11; only in the thickest portion does it come so as to have a **two-layer structure of silicon oxide film 11 and organic film 10** (figure 3)." (Emphasis added; page 5 of translation, lines 5-14).

Morita does not teach chemical vapor depositing the dielectric.

Matsuura teaches the benefits of using plasma-enhanced CVD plus a "dry" oxygen-containing compound (hydrogen peroxide or H_2O_2) *instead of liquid-phase deposition* of forming the dielectric layer of **Morita** consisting essentially of $(CH_3)_xSiO_y$ (methyl silicon oxide) over at least partially formed integrated circuits. (See **Matsuura**, Fig. 2, column 2, lines 14-30; columns 4-7). Note that hydrogen peroxide fully meets the definition provided by Applicant's specification at page 7, lines 5-7 anyway because hydrogen peroxide is not and does not contain water. Nor does hydrogen peroxide decompose to form water. Rather, it is well known that the thermodynamically preferred decomposition path of hydrogen peroxide is to form hydroxyl radicals which are not water. Note that decomposition is distinct from reacting to form water, but this is not supported by Applicant's specification, in particular because the precursor used to form the $(CH_3)_xSiO_y$ layer has active hydrogen that will form water upon reaction with the oxygen precursor.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify any of **Morita** to use PECVD to deposit the methyl silicon oxide, for the benefits indicated in **Matsuura** -- especially that PECVD is better than liquid phase deposition.

It is held absent evidence to the contrary that the dielectric constant is reduced by at least 10% by exposure to the oxygen plasma and that the dielectric constant is inherently stabilized. If

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it is thought for some reason that the dielectric constant is not reduced or is not stabilized by exposure to the oxygen plasma, then these may be a difference. But, it has been held, where the Patent Office has reason to believe that a functional limitation asserted to be critical for establishing novelty in the claimed subject matter may, in fact, be an inherent characteristic of the prior art, it possesses the authority to require the applicant to prove that subject matter shown to be in the prior art does not possess the characteristics relied on. See In re Swinhart, 169 USPQ 226,229 (CCPA 1971). See also In re Fitzgerald, 205 USPQ 594 (CCPA 1980) (the burden of proof can be shifted to the applicant to show that subject matter of the prior art does not possess the characteristic relied on whether the rejection is based on inherency under 35 USC 102 or obviousness under 35 USC 103). Given the similarity (if not equality) of the dielectric materials formed, the present evidence indicates that the dielectric constant must necessarily be reduced and stabilized.

Regarding claims 82-84, 86, and 87, **Matsuura** does not indicate that the oxygen in the oxygen plasma may come from any of O₂, O₃, N₂O, and NO_x or combinations thereof, Examiner repeats the unchallenged official notice that O₂, O₃, N₂O, and NO_x are notoriously well known sources of oxygen in plasmas resulting from the plasma-induced decomposition into, among other products, highly reactive oxygen radicals. It would have been obvious to one of ordinary skill in the art at the time the invention was made to use O₂, O₃, N₂O, or NO_x as the source of oxygen in the plasma as a matter of design choice of art recognized equivalents of plasma oxygen sources, or of routine optimization, in order to gain the best oxygen radical source of known oxygen

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sources for the purpose at hand. Additionally, the specification provided absolutely no evidence of unexpected results for any specific oxygen compound or for any of the selected combinations now claimed. One of ordinary skill could easily practice the invention with a reasonable expectation of success using any known oxygen-containing precursor which is known to provide active oxygen in plasma.

Regarding claim 90, although the upper temperature limit for plasma exposure is not indicated in **Morita**, the choice of temperature is matter of routine optimization with a limited number of species and obvious to one of ordinary skill. See In re Aller, 105 USPQ 233 (CCPA 1955) (selection of optimum ranges within prior art general conditions is obvious). It would have been obvious to one of ordinary skill in the art at the time the invention was made to stay below an exposure temperature of 550°C to prevent degradation to the organic portion of methyl silicon oxide which portion is clearly desired to be retained in **Morita** to retain the desired properties associated with the methyl silicon oxide. It would have been obvious to one of ordinary skill in the art at the time the invention was made to optimize the exposure time as per the precedent above to optimize the resulting dielectric properties.

Regarding claim 98, if it is believed that there exist support from the specification for this range of exposure time, it has been held that claimed ranges of a result effective variable, which do not overlap the prior art ranges, are unpatentable unless they produce a new and unexpected result which is different in kind and not merely in degree from the results of the prior art. See In re Huang, 40 USPQ2d 1685, 1688(Fed. Cir. 1996). In the instant case, there exists no evidence of

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record to indicate that some unexpected result arises from the claimed time range relative to that in the applied art.

Regarding claim 100, it is held absent evidence to the contrary that the dielectric layer of either of **Morita** and **Matsuura** has at least 10 to 50 mol% of methyl groups before and after exposure, based on the molecular formulas indicated therein from which the organic silicon oxide layer is formed or its final form and because only the surface portion is modified by the exposure to oxygen plasma. Furthermore, Applicant has not indicated any criticality to the claimed portions. See In re Hoeschele, 406 F.2d 1403, 160 USPQ 809 (CCPA 1969) (Claimed elastomeric polyurethanes which fell within the broad scope of the references were held to be unpatentable thereover because, among other reasons, there was *no evidence of the criticality* of the claimed ranges of molecular weight or molar proportions.). Any difference is a matter of routine optimization within prior art general conditions which is obvious as per the precedent indicated above including In re Aller.

6. Claims **81-88**, 90-101 are rejected under 35 U.S.C. 103(a) as obvious over **Brinker** et al. (US 5,948,482) in view of **Matsuura** (US 6,124,641).

Brinker discloses forming a low-dielectric-constant material comprising, *inter alia*, methyl silicon oxide which inherently has a dielectric constant of less than 3.5 over an integrated circuit (column 1, lines 17-28; column 4, lines 8-15); blanket exposing the dielectric to oxygen plasma (column 5, lines 11-33) which is inherently effective to reduce the dielectric constant.

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Note that oxygen plasma exposure is used to “confer additional porosity” which inherently reduces the dielectric constant by at least 10% by incorporating more air or vacuum into the silicon oxide matrix (column 5, lines 25-29). Note that a whole of the dielectric layer is not converted from one base to another and that the $(\text{CH}_3)_x\text{SiO}_y$ remains as $(\text{CH}_3)_x\text{SiO}_y$. (See column 5, lines 29-33). (See also column 3, lines 29-30; column 8, Table 1).

Brinker does not teach chemical vapor depositing the dielectric.

Matsuura teaches the benefits over liquid-phase deposition of forming the dielectric layer of **Brinker** consisting essentially of $(\text{CH}_3)_x\text{SiO}_y$ (methyl silicon oxide) over at least partially formed integrated circuits, using plasma-enhanced CVD plus and an oxygen-containing compound (H_2O_2). (See **Matsuura**, Fig. 2; column 2, lines 14-30; columns 4-7).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify any of **Brinker** to use PECVD to deposit the methyl silicon oxide, for the benefits indicated in **Matsuura**.

The same reasoning regarding inherency used above is applied here.

The same reasoning applied to claims 82-84, 86, and 87, as used above, is applied here.

Regarding claims 95-99, although the exposure time and temperature is not indicated in **Brinker**, the choice of temperature and exposure time are a matter of routine optimization with a limited number of species and obvious to one of ordinary skill. See In re Aller, 105 USPQ 233 (CCPA 1955) (selection of optimum ranges within prior art general conditions is obvious). It would have been obvious to one of ordinary skill in the art at the time the invention was made to

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optimize the exposure time and temperature as per the precedent above to optimize the process in **Brinker**.

Regarding claim 100, although **Brinker** does not indicate the beginning and ending concentration of methyl groups in the range of 10% to 50%, **Brinker** indicates that only some of the organic groups are removed and that the amount removed is according to the desired properties such as porosity (i.e. dielectric constant) and hydrophobicity desired in the interlayer dielectric. It would have been obvious to one of ordinary skill in the art at the time the invention was made to choose 10 to 50 mol% of carbon as a matter of routine optimization in order to optimize the properties as indicated by **Brinker** and according to established precedent, *supra*.

7. Claim 89 is rejected under 35 U.S.C. 103(a) as being unpatentable over either of **Morita** and **Brinker**, either in view of **Matsuura** as applied to claims 81-88, 90-101 above, and in further view of **Miyasaka** (US 6,017,779).

The prior art as explained above discloses all of the limitations of the claimed invention except for (1) depositing the $(CH_3)_xSiO_y$ layer and exposing in the same chamber is not taught (Applicant's claims 8 and 34); and (2) shutting off the silicon process gas and maintaining conditions in the chamber to expose the dielectric to the oxygen plasma is not taught (Applicant's claim 35).

Miyasaka teaches a method of forming a silicon oxide layer on a semiconductor device using plasma-enhanced CVD with silicon-containing compound and a oxygen-containing gas and

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then shutting off the silicon-containing precursor and then exposing to the oxygen plasma in the same chamber maintained at sub-atmospheric pressure. (See **Miyasaka**, column 44, "Example 6" especially lines 35-52.)

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify either of **Brinker** or **Morita**, either in view of **Matsuura** to maintain a device in a single chamber as taught by **Miyasaka** in order to beneficially prevent contamination to the semiconductor device dielectric layer between process steps, as is well known in the art to do.

Response to Arguments

8. Applicant's arguments filed 9/25/01 have been fully considered but they are not persuasive.

Applicant's arguments regarding "dry" oxygen-comprising moiety are not considered persuasive. First, Applicant's specification expressly defines "dry" as directed to the oxygen-comprising "precursor" used to form the initial $(\text{CH}_3)_x\text{SiO}_y$ layer -- not for the oxygen exposure used to reduce the dielectric constant of the as-formed $(\text{CH}_3)_x\text{SiO}_y$ layer, as noted above. There is simply no support in the specification for this limitation. Assuming, *arguendo*, that there exists support from the specification for the oxygen exposure to include a "dry" oxygen moiety for the oxygen-exposing step used to reduce the dielectric constant, hydrogen peroxide fully meets the definition provided by Applicant's specification at page 7, lines 5-7 anyway because hydrogen peroxide is not and does not contain water. Nor does hydrogen peroxide decompose to form water. Nor is there any evidence of record to indicate the hydrogen peroxide decomposes

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according to the methods used in the instant invention to form water. Rather, it is well known that the thermodynamically preferred decomposition path of hydrogen peroxide is to form hydroxyl radicals which are not water. Further in this regard, the specification provides no support for the absence of water according to the methods used -- particularly the fact that the organo-silicon precursor used and the layer formed, $(\text{CH}_3)_x\text{SiO}_y$, have reactive hydrogen that will necessarily produce water upon exposure to the oxygen-containing moiety. Oxygen plasma, for instance, "ashes" organic material to produce carbon dioxide and water, among other things. So it is unclear how the presence of water could make a difference in the instant invention. Accordingly, the argument is not found persuasive.

Applicant argues that the claimed method is different from the applied art because the $(\text{CH}_3)_x\text{SiO}_y$ layer is "on" the substrate. This argument is debunked by Applicant's express definition of "substrate" as stated on page 5, lines 13-23. The definition states in pertinent part that the substrate includes the semiconductive material and "other materials thereon." Therefore, the substrate of the applied art references meets Applicant's express definition which includes other layers. Furthermore, the specification indicated that the $(\text{CH}_3)_x\text{SiO}_y$ layer is formed "over" the substrate which further corroborates the argument just forwarded.

Applicant suggests that the combination of either of Brinker and Morita with Matsuura is not proper. Examiner respectfully disagrees. Matsuura expressly indicates that PECVD of $(\text{CH}_3)_x\text{SiO}_y$ is better than spin-on or liquid methods, as previously indicated. Accordingly, one of ordinary skill would be motivated to follow this express suggestion.

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Further regarding Brinker, Applicant appears to allege that Brinker is not applicable because, "Brinker et al. is not directed to a chemical vapor deposition process, and accordingly, could not suggest conducting Applicant's recited 'exposing' in any chemical vapor deposition chamber, let alone the same one within which the chemical vapor deposition occurs on a subject substrate." Examiner respectfully disagrees. In light of the applied references, which are Brinker in view of Matsuura or Brinker in view of Matsuura and in further view of Miyasaka-- not over Brinker alone, there is a clear suggestion in Matsuura that PECVD is better than liquid phase deposition. Furthermore, Applicant has provided no evidence whatsoever that the method of Brinker could not be carried out in a CVD chamber. The method of depositing and treating in the same PECVD chamber is clearly advantageously applied in Miyasaka which suggests to one of skill to apply its benefits to Brinker in view of Matsuura.

Regarding Applicant's speculation that the porosities of Brinker could not be reached with the method of Matsuura, this argument is irrelevant as drawn to a conclusory observation made by Applicant's Representative and to material that is not claimed. Applicant is invited to provide evidence as to prove such porosities could not be met. Furthermore, given that the oxygen exposure is performed at temperatures below the reflow temperature of the $(\text{CH}_3)_x\text{SiO}_y$ layer, porosity is necessarily created in the portion of the $(\text{CH}_3)_x\text{SiO}_y$ layer exposed to the oxygen because material is removed without reflow, thereby necessarily leaving pored behind.

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Conclusion

9. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire **THREE MONTHS** from the mailing date of this action. In the event a first reply is filed within **TWO MONTHS** of the mailing date of this final action and the advisory action is not mailed until after the end of the **THREE-MONTH** shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than **SIX MONTHS** from the date of this final action.

Any inquiry concerning this communication from examiner should be directed to Erik Kielin whose telephone number is (703) 306-5980 and e-mail address is erik.kielin@uspto.gov. The examiner can normally be reached by telephone on Monday through Thursday 9:00 AM until 7:30 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Charles Bowers, can be reached at (703) 308-2417 or by e-mail at charles.bowers@uspto.gov. The fax phone number for the group is (703) 308-7722 or -7724.

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December 19, 2001

Charles D. Bowers Jr.

Charles Bowers
Supervisory Patent Examiner
Technology Center 2800